forming a lower electrode layer of said ferroelectric capacitor over said insulation film;

forming a **PZT** ferroelectric film on said lower electrode layer as a capacitor insulation film of said ferroelectric capacitor;

crystallizing said **PZT** ferroelectric film by applying a thermal annealing process in an atmosphere containing a non-oxidizing gas and an oxidizing gas; and

forming an upper electrode layer on said **PZT** ferroelectric film,

wherein said step of crystallizing said PZT ferroelectric film is conducted by setting the composition of said atmosphere such that said atmosphere contains said oxidizing gas with a fraction of 1 – 50% by volume, and wherein said method further comprises the step, after said step of crystallizing said **PZT** ferroelectric film, of oxidizing said ferroelectric film in an oxidizing atmosphere.

REMARKS

A. Summary of the Office Action

Claims 1-2, 4-14 and 21-28 stand rejected under 35 U.S.C. § 103(a) as being unpatentable over *Cuchiaro et al.* (U.S. Patent No. 6,165,802) in view of *Solayappan et al.* (U.S. Patent No. 6,245,580) and *Ushikubo et al.* (U.S. Patent No. 5,851,841).

Claims 15-20 stand rejected under 35 U.S.C. § 103(a) as being unpatentable over *Izuhu et al.* (U.S. Patent No. 6,060,735) in view of *Duncombe et al.* (U.S. Patent No. 6,172,385).

B. Rejection Under 35 U.S.C. § 103(a) of Claims 1-2, 4-14 and 21-28 over the combination of *Cuchiaro, Solayappan and Ushikubo* Addressed.

Applicant respectfully traverses the rejections of claims 1-2, 4-14 and 21-28 over the combination of *Cuchiaro, Solayappan and Ushikubo*, and requests reconsideration.

Independent claim 1, as amended, recites a method of fabricating a semiconductor device which includes the steps of

> forming a **PZT** ferroelectric film on said lower electrode layer as a capacitor insulation film of said ferroelectric capacitor;

crystallizing said **PZT** ferroelectric film by applying a thermal annealing process in an atmosphere containing a non-oxidizing gas and an oxidizing gas; and

forming an upper electrode layer on said **PZT** ferroelectric film,

wherein said step of crystallizing said **PZT** ferroelectric film is conducted by setting a composition of said atmosphere such that said atmosphere contains said oxidizing gas with a fraction of 1 to 50% in volume.

Similarly, independent claim 21 includes the following steps:

forming a **PZT** ferroelectric film on said lower electrode layer as a capacitor insulation film of said ferroelectric capacitor;

crystallizing said **PZT** ferroelectric film by applying a thermal annealing process in an atmosphere containing a non-oxidizing gas and an oxidizing gas; and

forming an upper electrode layer on said **PZT** ferroelectric film,

wherein said step of crystallizing said PZT ferroelectric film is conducted by setting the composition of said atmosphere such that said atmosphere contains said oxidizing gas with a fraction of 1 – 50% by volume, and wherein said method further comprises the step, after said step of crystallizing said **PZT** ferroelectric film, of oxidizing said ferroelectric film in an oxidizing atmosphere.

The claims have been amended to clarify that the ferroelectric material most relevant to the present invention relates to PZT (lead-zirconate-titanate) ferroelectric films, which would be understood by one of ordinary skill in the art to include both undoped PZT films and PZT films doped with other materials, for example, lanthanum (PLZT). Support for these amendments is found at page 2, lines 32-37 and elsewhere in the specification.

As noted in the Office Action, *Cuchiaro* does not teach or suggest a thermal annealing process in an atmosphere containing a non-oxidizing gas and an oxidizing gas.

Newly cited *Soayappan* teaches a process of forming an SBT film by a sol-gel process, followed by a baking process conducted in air. However, *Solayappan* is directed completely to SBT (strontium-bismuth-tantalate) films. While SBT is a ferroelectric material, it is known as a "superlattice" material containing two alternating crystal structure layers at a microscopic level. This is a different structure from the PZT crystal structure. The chemical arts being known for their unpredictability, there is no reason to presuppose that the

annealing teaching of *Solayappan* could be combined with *Cuchiaro*. In other words, there is no teaching in *Solayappan* which suggests the SBT anneal processes taught there will work with PZT.

Of course the mere fact that references can be combined or modified is insufficient unless the prior art suggests the desirability of the combination. *In re Mills*, 916 F.2d 680 (Fed. Cir. 1990); *In re Fritch*, 972 F.2d 1260 (Fed. Cir. 1992). Because it is the prior art which must suggest the desirability, the conclusion in the Office Action at page 3 that the motivation for combining these references "would be to produce a satisfactory ferroelectric film for [a] ferroelectric capacitor" is legally insufficient.[1]

Since the applied references fail to meet the requirement for establishing a *prima facie* case with respect to amended claims 1 and 21, Applicant respectfully requests that the rejection of claims 1 and 21 under 35 U.S.C. § 103(a) be withdrawn.

With regard to dependent claims 2, 4-14 and 22-28, Applicant submits that the claims are allowable at least because they depend from and incorporate all the features of allowable claim 1 or 21, and for the same reasons that claims 1 and 21 are allowable. Accordingly, Applicant respectfully requests that the rejections of claims 2, 4-14 and 22-28 under 35 U.S.C. § 103(a) be withdrawn.

C. Rejection Under 35 U.S.C. § 103(a) of Claims 15-20 over the combination of *Izuha* and *Duncombe* Addressed.

Applicant respectfully traverses the rejections of claims 15-19 under 35 U.S.C. § 103(a) as being unpatentable over *Izuha* in view of *Duncombe* and requests reconsideration. Claim 20 has been cancelled, mooting the rejection of claim 20.

Independent claim 15 recites a semiconductor device including

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1 *See, also, Ex parte Levengood*, 28 U.S.P.Q.2d 1300 (Bd. Pat. Appeals & Inter. 1993) (the statement that the modifications would have been well within the ordinary skill of the art because the individual aspects of the claimed invention were known is not sufficient to establish a *prima facie* case without a reason to combine the teachings).

> a **PZT** ferroelectric film provided on said lower electrode, said **PZT** ferroelectric film having a columnar microstructure extending from an interface between said lower electrode and said **PZT** ferroelectric film in a direction substantially perpendicular to a principal surface of said lower electrode, said **PZT** ferroelectric film essentially consisting of crystal grains having a generally uniform grain diameter of less than about 200 nm.

The references, whether taken individually or in combination, do not teach or suggest at least this element of claim 15.

Izuha, the primary reference, is not enabling as to PZT. Its numerous examples are concerned with SBT or with SRO (strontium-ruthenium-oxygen). As discussed above, the complexity and unpredictability of the chemical arts prevents one from assuming that the beneficial structure of *Izuha* would necessarily translate to the PZT films of claim 15. Since *Duncombe* does not provide any PZT teachings, *prima facie* obviousness has not been established for amended claim 15 or for dependent claims 16-19, which include the PZT ferroelectric film limitation through their dependence upon amended claim 15.

Since, the Office Action fails to establish a *prima facie* case of obviousness as to claims 15-19 for the reasons set forth above, Applicant respectfully requests that the rejection of claims 15-19 under 35 U.S.C. § 103(a) be withdrawn.

D. Conclusion.

Applicant respectfully requests the reconsideration and the timely allowance of the pending claims. Should the Examiner feel that there are any issues outstanding after consideration of this response, the Examiner is asked to telephone the undersigned to expedite prosecution. Please charge any fees associated with this transmittal to Deposit Account No. 50-1123.

Respectfully submitted,

November 23, 2001

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CLEAN COPIES OF AMENDED CLAIMS

1. (Twice Amended) A method of fabricating a semiconductor device having a ferroelectric capacitor, comprising the steps of:

forming an active device element on a substrate;

forming an insulation film over said substrate to cover said active device element;

forming a lower electrode layer of said ferroelectric capacitor over said insulation film;

forming a PZT ferroelectric film on said lower electrode layer as a capacitor insulation film of said ferroelectric capacitor;

crystallizing said PZT ferroelectric film by applying a thermal annealing process in an atmosphere containing a non-oxidizing gas and an oxidizing gas; and

forming an upper electrode layer on said PZT ferroelectric film, wherein said step of crystallizing said PZT ferroelectric film is conducted by setting a composition of said atmosphere such that said atmosphere contains said oxidizing gas with a fraction of 1 to 50% in volume.

15. (Amended) A semiconductor device, comprising:

a substrate;

an active device element formed on said substrate;

an insulation film provided over said substrate to cover said active device element;

a lower electrode provided over said insulation film;

a PZT ferroelectric film provided on said lower electrode, said PZT ferroelectric film having a columnar microstructure extending from an interface between said lower electrode and said PZT ferroelectric film in a direction substantially perpendicular to a principal surface of said lower electrode, said PZT ferroelectric film essentially consisting of crystal grains having a generally uniform grain diameter of less than about 200 nm; and

an upper electrode provided on said PZT ferroelectric film.

16. (Amended) A semiconductor device as claimed in claim 15, wherein said crystal grains constituting said PZT ferroelectric film have an average diameter of about 150 nm.

19. (Amended) A semiconductor device as claimed in claim 17, wherein said PZT ferroelectric film has a perovskite structure.

21. (Amended) A method of fabricating a semiconductor device having a ferroelectric capacitor, comprising the steps of:

forming an active device element on a substrate;

forming an insulation film over said substrate to cover said active device element;

forming a lower electrode layer of said ferroelectric capacitor over said insulation film;

forming a PZT ferroelectric film on said lower electrode layer as a capacitor insulation film of said ferroelectric capacitor;

crystallizing said PZT ferroelectric film by applying a thermal annealing process in an atmosphere containing a non-oxidizing gas and an oxidizing gas; and

forming an upper electrode layer on said PZT ferroelectric film,

wherein said step of crystallizing said PZT ferroelectric film is conducted by setting the composition of said atmosphere such that said atmosphere contains said oxidizing gas with a fraction of 1 – 50% by volume, and wherein said method further comprises the step, after said step of crystallizing said PZT ferroelectric film, of oxidizing said ferroelectric film in an oxidizing atmosphere.